ENDOCRINE MODULE
PHYSIOLOGY (LECTURE 1)
HYPOTHALAMIC PITUITARY RELATIONSHIP

BY

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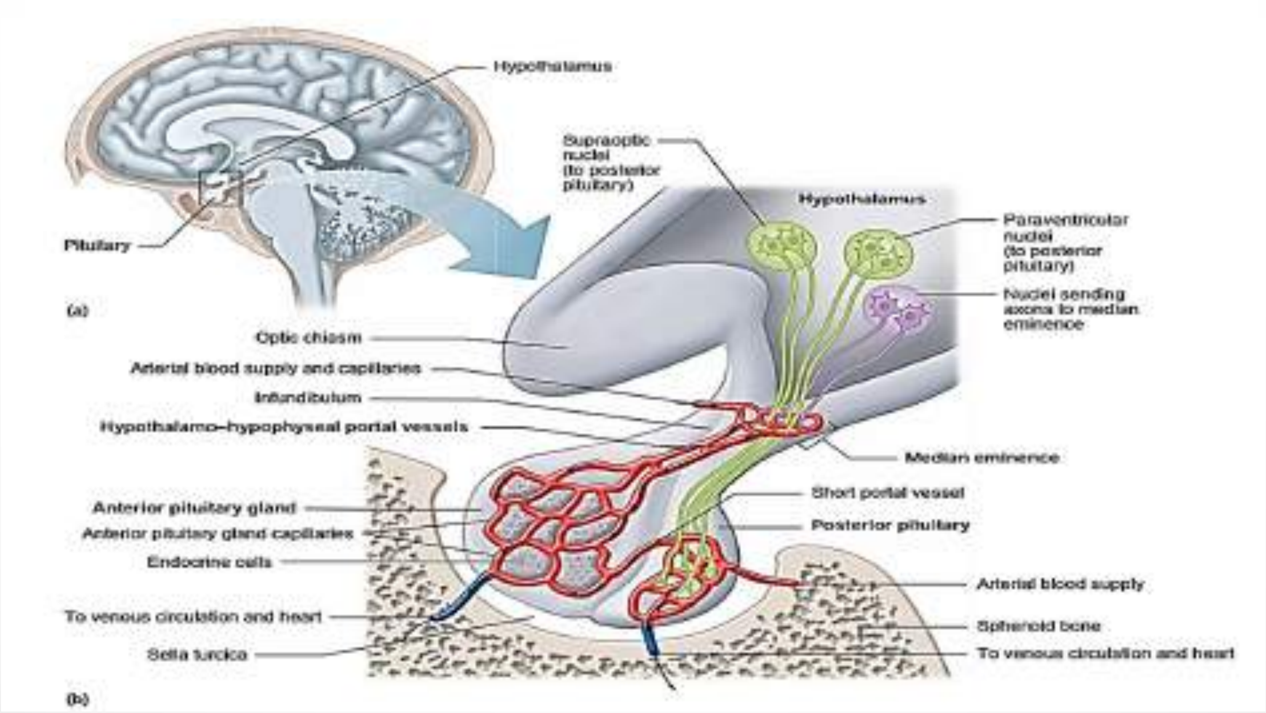
2024-2025



CONTROL SYSTEMS

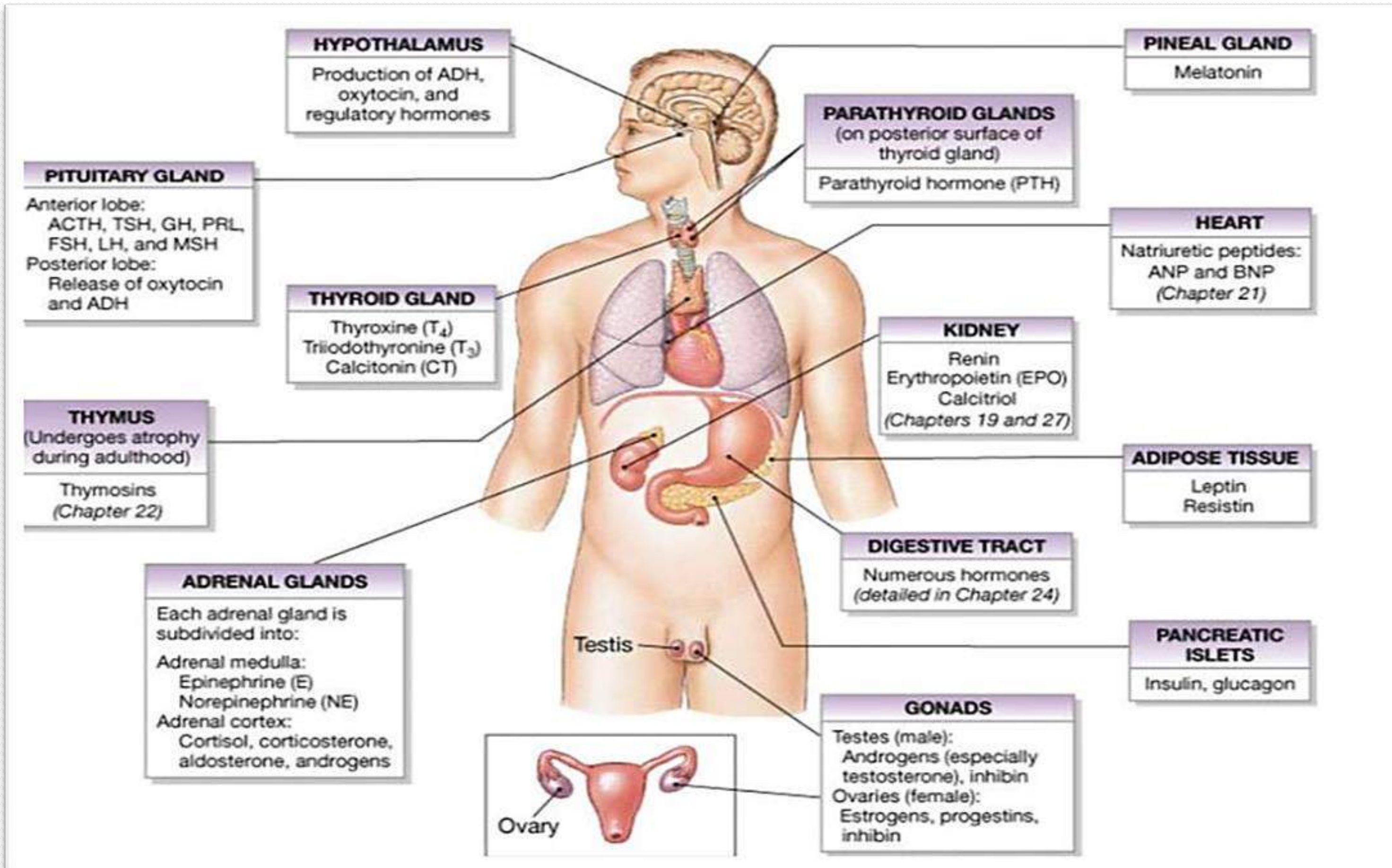
The different body activities are regulated by two main systems:

- **Nervous system:** It is **a rapid control system**. So, its response is **rapid and transient.**
- **Endocrine System:** which is made up of **ductless glands** secreting chemical substances called **hormones** directly into the bloodstream through which they reach other sites (target organs). It is a **slow control system**. So, its **response is slow and prolonged**.

Endocrine glands include:

- Pituitary gland (hypophysis).
- Thyroid gland.
- Parathyroid glands.
- Adrenal (suprarenal) glands (each contains cortex and medulla).
- Gonads (2 testes in males and 2 ovaries in females).
- Islets of Langerhans (in Pancreas).

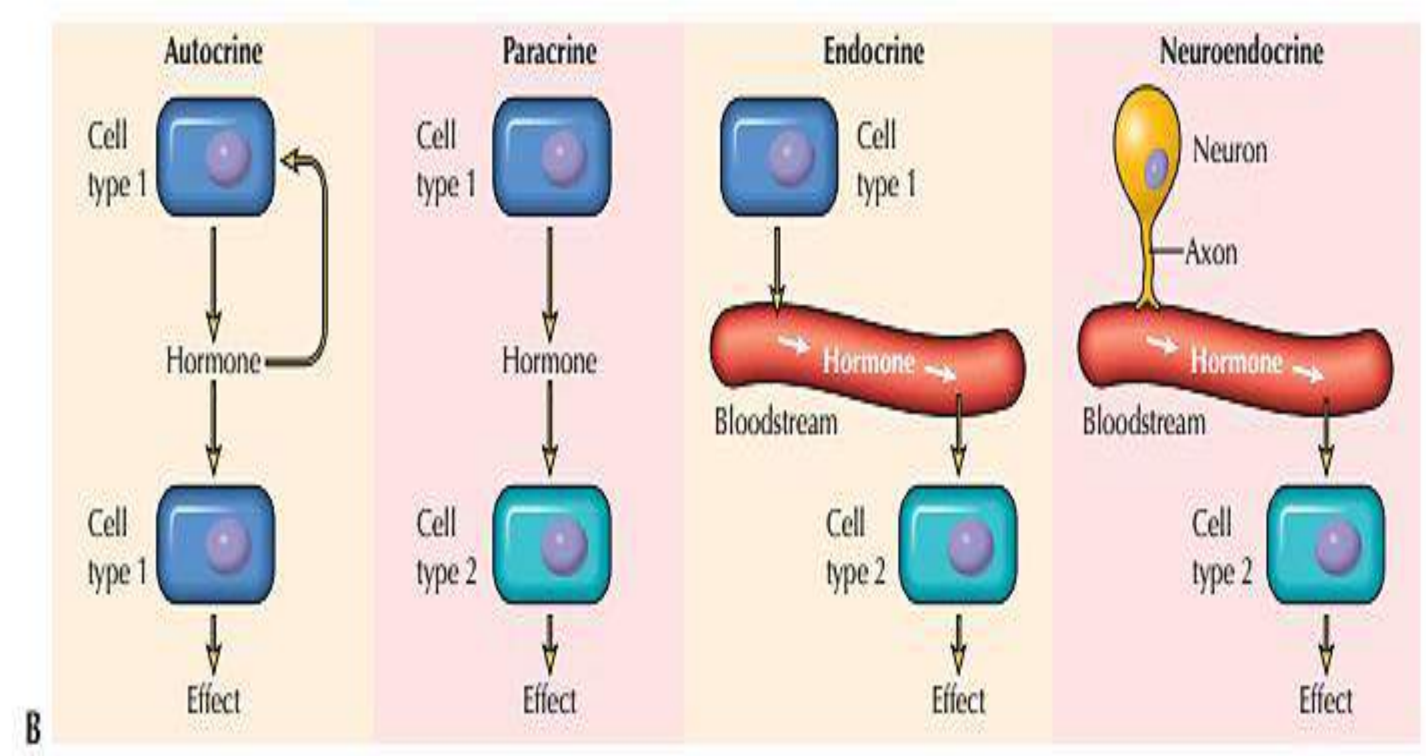
N.B. There are organs that have endocrine functions.


HYPOTHALAMUS
Production of ADH, oxytocin, and regulatory hormones
PINEAL GLAND
Melatonin
PARATHYROID GLANDS (on posterior surface of thyroid gland)
Parathyroid hormone (PTH)
PITUITARY GLAND
Anterior lobe: ACTH, TSH, GH, PRL, FSH, LH, and MSH
Posterior lobe: Release of oxytocin and ADH
HEART
Natriuretic peptides: ANP and BNP (Chapter 21)
THYROID GLAND
Thyroxine (T_4)
Triiodothyronine (T_3)
Calcitonin (CT)
KIDNEY
Renin
Erythropoietin (EPO)
Calcitriol
(Chapters 19 and 27)
THYMUS (Undergoes atrophy during adulthood)
Thymosins (Chapter 22)
ADIPOSE TISSUE
Leptin
Resistin
DIGESTIVE TRACT
Numerous hormones (detailed in Chapter 24)
ADRENAL GLANDS
Each adrenal gland is subdivided into:
Adrenal medulla: Epinephrine (E) Norepinephrine (NE)
Adrenal cortex: Cortisol, corticosterone, aldosterone, androgens
Testis
PANCREATIC ISLETS
Insulin, glucagon
GONADS
Testes (male): Androgens (especially testosterone), inhibin
Ovaries (female): Estrogens, progestins, inhibin
Ovary

Hypothalamus

- It is a part of the nervous system that is considered **as a link between the two systems**.
- It **controls the master gland (anterior pituitary gland) that controls most other (but not all) endocrine glands**.

- **Endocrine hormones** are released by **endocrine glands** into the circulating blood and influence the function of cells at another location in the body.
- **Neuroendocrine hormones:** Are secreted by **neurons** into the **circulating blood** & influence the function of target cells at another location in the body. **Oxytocin and ADH**.
- **Paracrine:** are secreted by cells into the extracellular fluid and affect neighboring cells.
- **Autocrine:** are secreted by cells into the extracellular fluid and affect the function of the same cells that produced them by binding to cell surface receptors.



Autocrine
Cell type 1
Hormone
Cell type 1
Effect
Paracrine
Cell type 1
Hormone
Cell type 2
Effect
Endocrine
Cell type 1
Hormone
Bloodstream
Cell type 2
Effect
Neuroendocrine
Neuron
Axon
Hormone
Bloodstream
Cell type 2
Effect
B

What is a hormone ?

It is a chemical substance secreted into the blood stream by endocrine glands (or tissues) to act on distant organs called effector (target) organs where they affect the physiological processes.

Properties of hormones:

1. They are secreted in very small amounts that maintain a basal quantity of each hormone in bloodstream and the rate of secretion of a certain hormone depends on the needs of the body to this hormone.
2. They do not act on the organs secreting them (endocrine glands or tissues) but act on distant organs (effector organs).
3. Hormones may act on a **specific** effector organ e.g. thyroid stimulating hormone (TSH) of the anterior pituitary acts specifically on the thyroid gland, or hormones may act on the body as a whole (**generalized**) e. g. growth hormone (GH) of the anterior pituitary.

4. In target cells, hormones initiate certain biochemical reactions which often continue for sometime after disappearance of hormones from bloodstream.
5. **Stimuli that release a certain hormone inhibit the secretion of other hormones that exert antagonistic effects** e.g. hyperglycemia stimulates insulin secretion and inhibits secretion of its antagonists (e.g. glucagon and growth hormone)
6. Many hormones show **cyclic variations in their rate of secretion over the 24 hours (= diurnal or circadian rhythm) e.g. ACTH and melatonin**.
7. Some hormones are secreted in relatively inactive forms then converted in tissues to more active forms
8. Hormones circulate in bloodstream in 2 forms: **A free (active) form** and a **protein bound form** to plasma proteins (**reservoir** for the hormone).

THE PITUTARY GLAND (HYPOPHYSIS)

- The pituitary gland is a small gland lying in a small cavity (sella turcica) of the sphenoid bone at the base of the brain just below the hypothalamus.
- It is **connected to the hypothalamus by the pituitary stalk (infundibulum) containing axons from neurons in the hypothalamus and small blood vessels.**
- **In humans, It is divided into anterior and posterior lobes:**
- **Adenohypophysis (anterior lobe): made up of glandular tissue.**
- **Neurohypophysis (posterior lobe): the posterior pituitary is not actually a gland but, rather, an extension of the neural components of the hypothalamus. It is a neural tissue that receives, stores, and releases hormones from the hypothalamus.**

HORMONES OF THE PITUITARY GLAND

(1) Anterior Pituitary Hormones :

1. Growth Hormone (GH or Somatotropin).
2. Thyroid Stimulating Hormone (TSH, Thyrotropin).
3. Adrenocorticotropic Hormone (ACTH, Corticotropin).
4. Follicle Stimulating Hormone (FSH).
5. Luteinizing Hormone (LH).

Both FSH and LH are referred to as gonadotropic hormones (GnHs) or gonadotropins.

6. Prolactin (PRL), Mammotropin.

- **The anterior pituitary gland** is frequently called the **master gland** because it secrets tropic hormones that control most of the other endocrine glands (ACTH controls the adrenal cortex, TSH controls the thyroid gland, while GnHs control both male and female gonads).
- Tropic hormones stimulate secretion from other endocrine glands except somatotropin (GH) because it is a **systemic hormone** that is not tropic to any specific endocrine gland.

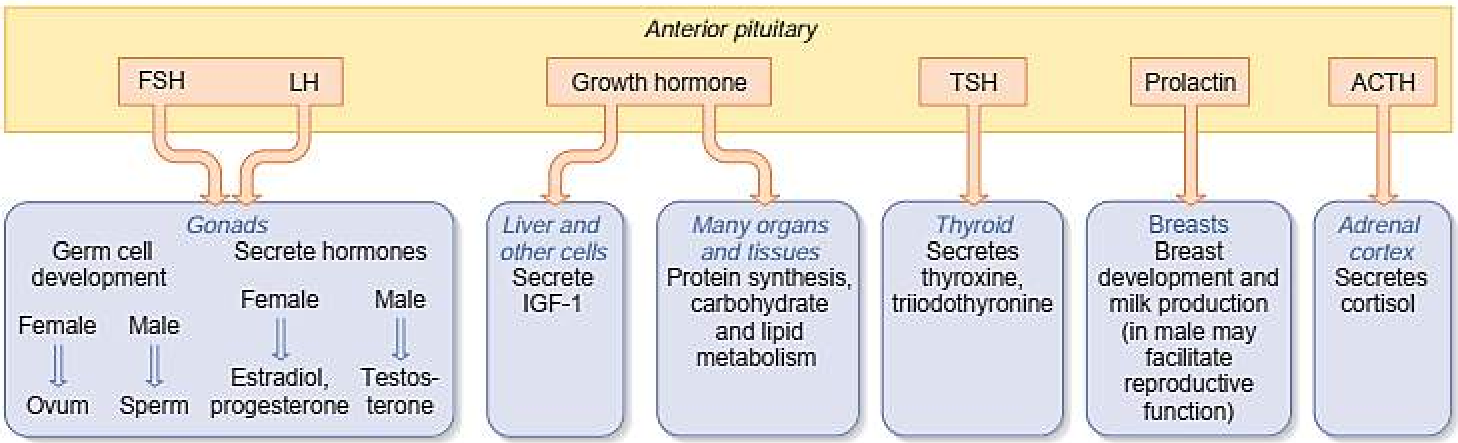
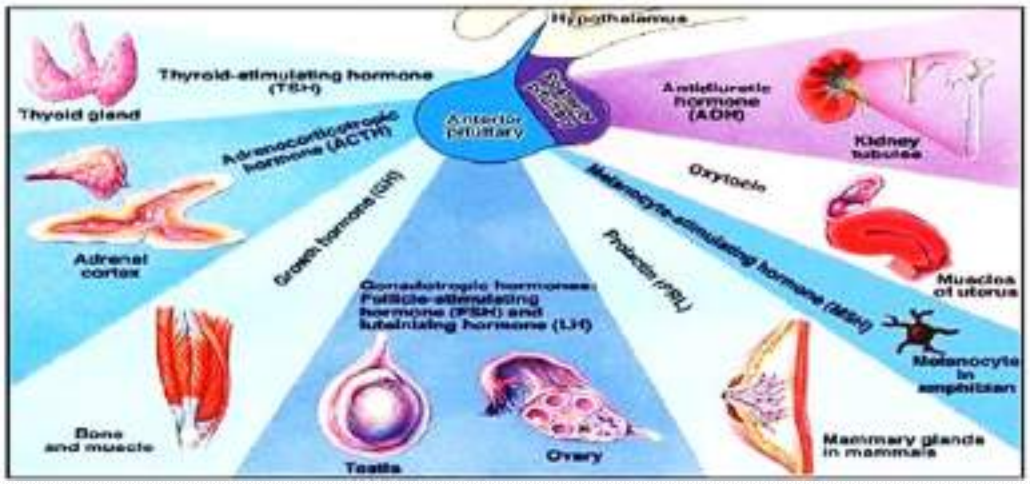


Figure 11.15 Targets and major functions of the six classical anterior pituitary gland hormones.

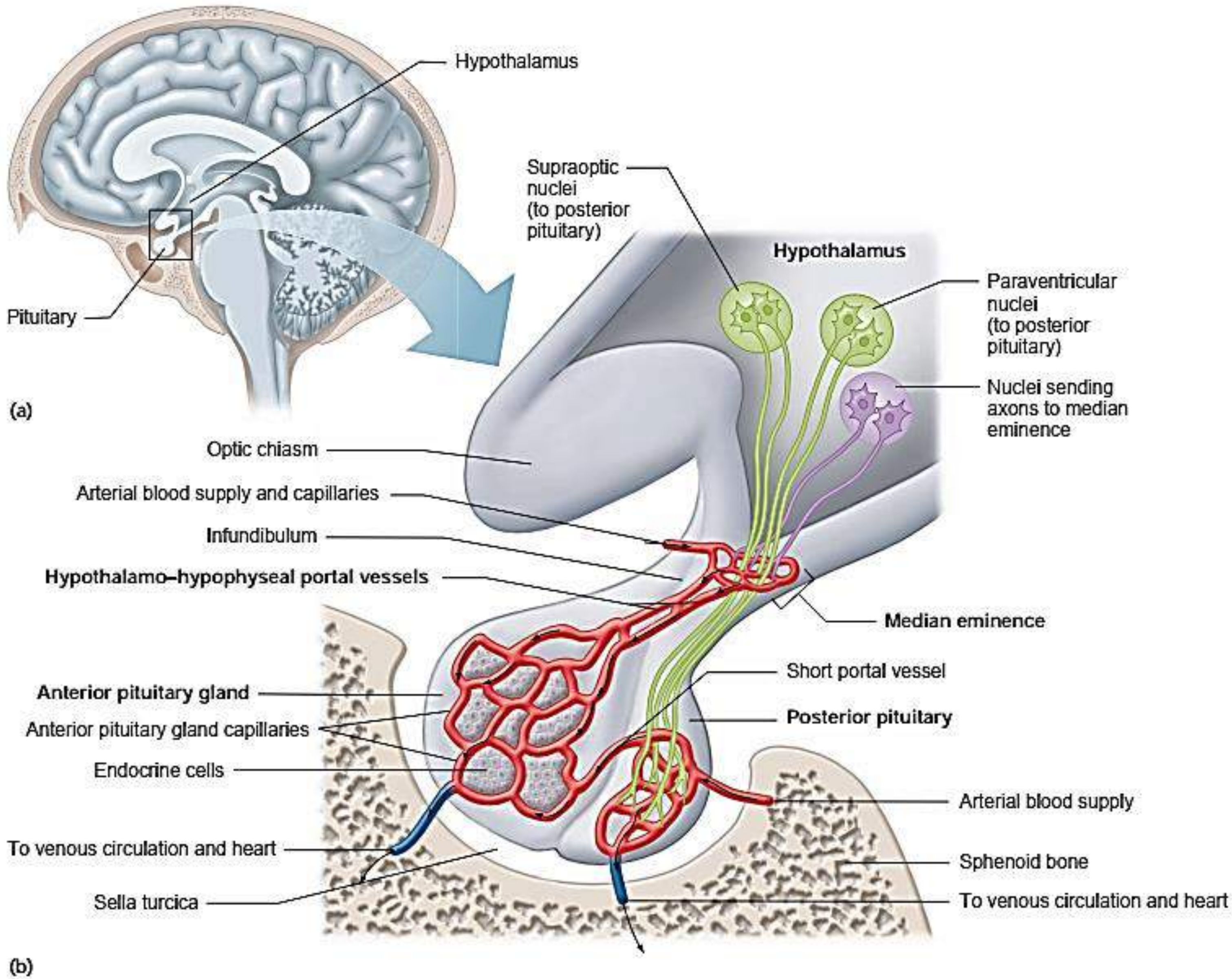
(2) Posterior Pituitary Hormones :

1. Antidiuretic Hormone (ADH, or Vasopressin).
2. Oxytocin.



The Hypothalamic Connections with the Pituitary Gland

- There are **2 types of connections between the hypothalamus and the pituitary gland** (which form a link between the nervous system and the gland):
- **A vascular (Circulatory) connection between the hypothalamus and the anterior pituitary gland in the form of a hypothalamo-hypophyseal portal circulation**.
- **A nervous (Neural) connection between the hypothalamus and posterior pituitary gland** in the form of a **hypothalamo-hypophyseal tract**.


Hypothalamus
Pituitary
(a)
Supraoptic nuclei (to posterior pituitary)
Hypothalamus
Paraventricular nuclei (to posterior pituitary)
Nuclei sending axons to median eminence
Optic chiasm
Arterial blood supply and capillaries
Infundibulum
Hypothalamo–hypophyseal portal vessels
Median eminence
Short portal vessel
Anterior pituitary gland
Posterior pituitary
Anterior pituitary gland capillaries
Endocrine cells
Arterial blood supply
To venous circulation and heart
Sphenoid bone
Sella turcica
To venous circulation and heart
(b)

Through these connections the hypothalamus acts as a control center to the endocrine system as follows:

- The hypothalamus secrets several hormones called **hypophysiotropic hormones**.
- **Hypophysiotropic hormones** are then released from the median eminence into the portal vessels through which they reach the **anterior pituitary gland** where they affect the secretion of its hormones. In this way, **the hypothalamus indirectly controls the activity of most of the endocrine system because the anterior pituitary gland secrets tropic hormones that control most of the other endocrine glands**.
- **The hypothalamus also secrets the 2 hormones of the posterior pituitary gland**, which are transported via the **hypothalamo-hypophyseal tract to the posterior pituitary gland** where they are **stored then released** when required by signals discharged from the hypothalamus.

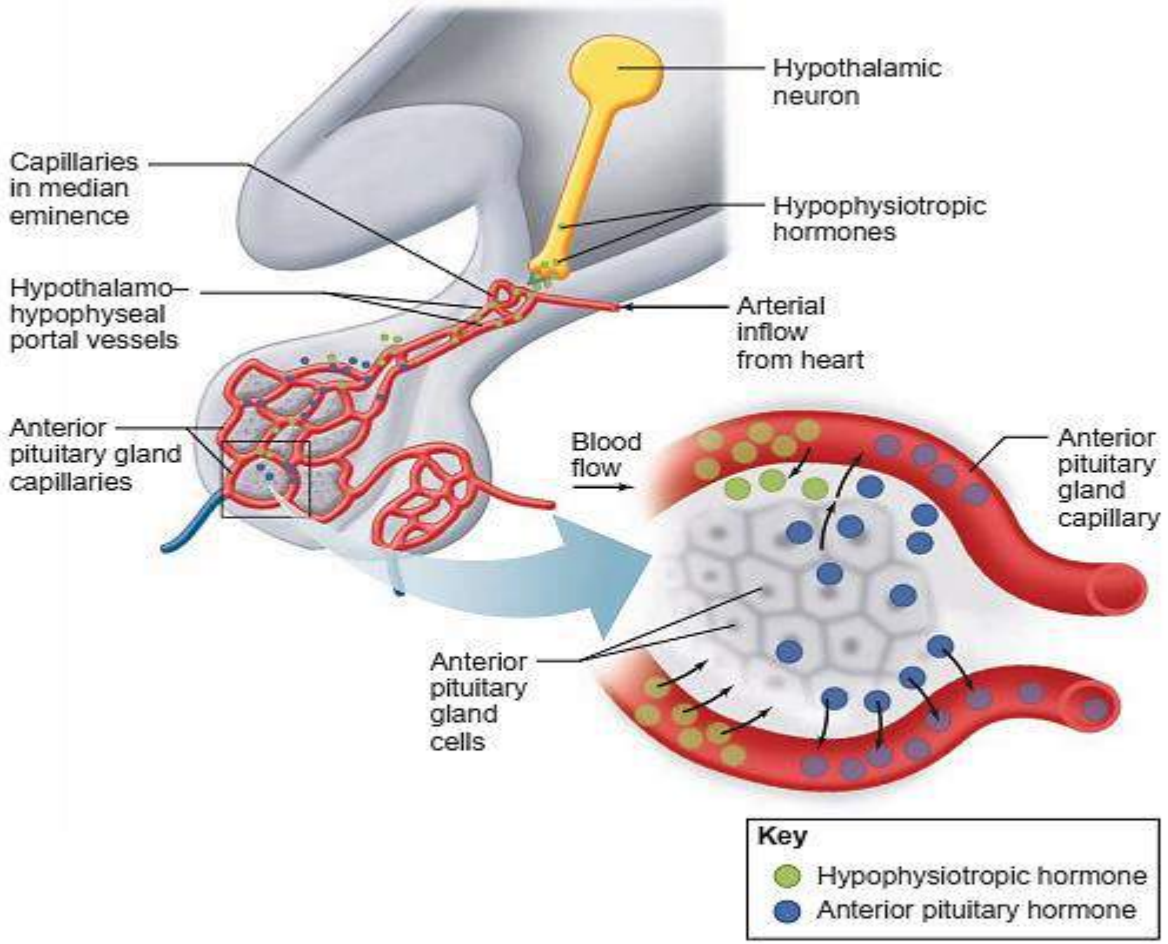


Figure 11.16 APR Hormone secretion by the anterior pituitary gland is controlled by hypophysiotropic hormones released by hypothalamic neurons and reaching the anterior pituitary gland by way of the hypothalamo–hypophyseal portal vessels.

Regulation (Control) of Anterior Pituitary Hormones Secretion

- The hormonal secretion by the anterior pituitary gland is regulated through the following mechanisms:

1. **The hypothalamic control.**
2. **Feedback control:**

- ✓ **Negative feedback:**
  - o **Long loop feedback** .
  - o **Short loop feedback** .
- ✓ **Positive feedback.**

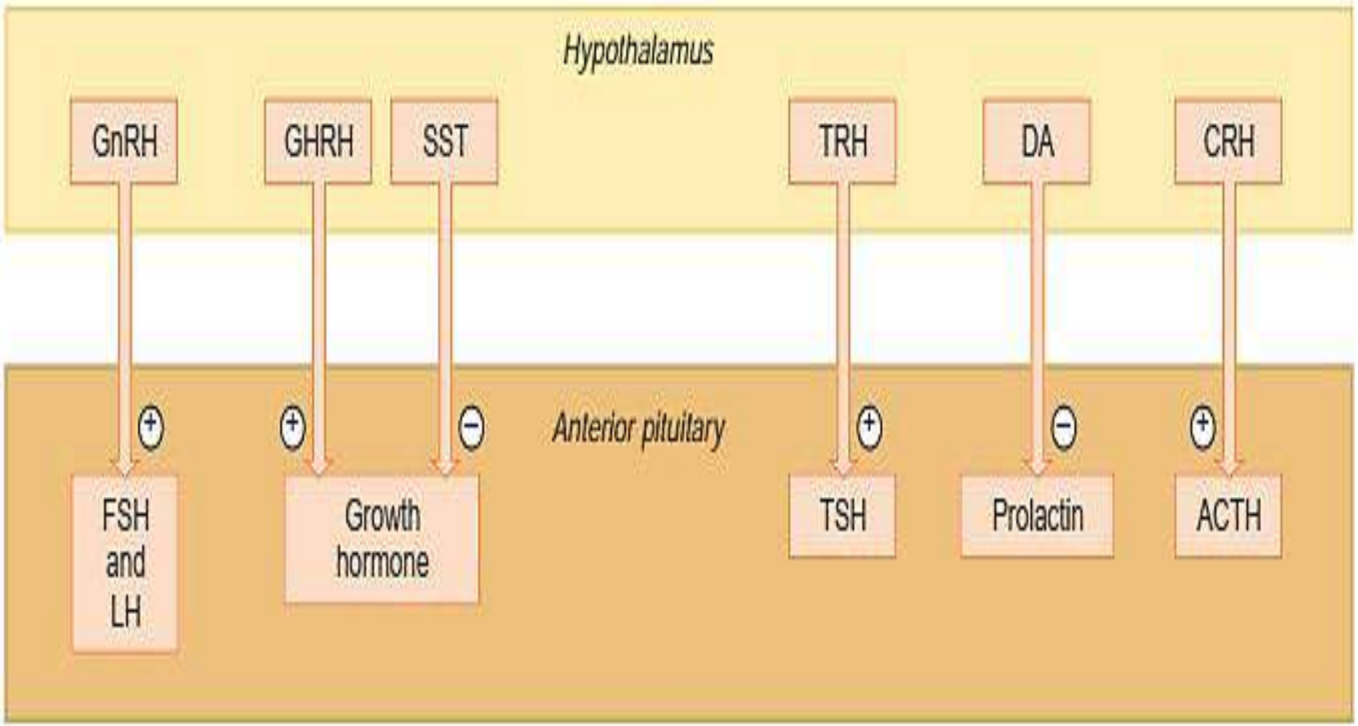
1. The Hypothalamic Control

- The hypothalamus controls the activity of anterior pituitary gland by releasing hormones called **hypophysiotropic hormones** that reach the gland via the **hypothalamo-hypophyseal portal circulation**.
- These hypothalamic hormones either stimulate the release of anterior pituitary hormones (= **releasing hormones**) or inhibit the release of these hormones (= **inhibiting hormones) .**

The Hypothalamic Hormones (Hypophysiotropic hormones)

- **Releasing hormones:**
  - Growth hormone-releasing hormone (GHRH).
  - Thyrotropin-releasing hormone (TRH).
  - Corticotropin-releasing hormone (CRH).
  - Gonadotropin-releasing hormone (GnRH).

- **Inhibiting hormones:**
  - Growth hormone-inhibiting hormone (GIH or somatostatin).
  - Prolactin – inhibiting hormone (PIH; dopamine).
- **All anterior pituitary hormones are controlled mainly by their releasing hormones except prolactin which is controlled mainly by PIH (dopamine).**


Hypothalamus
GnRH
GHRH
SST
TRH
DA
CRH
Anterior pituitary
FSH and LH
Growth hormone
TSH
Prolactin
ACTH

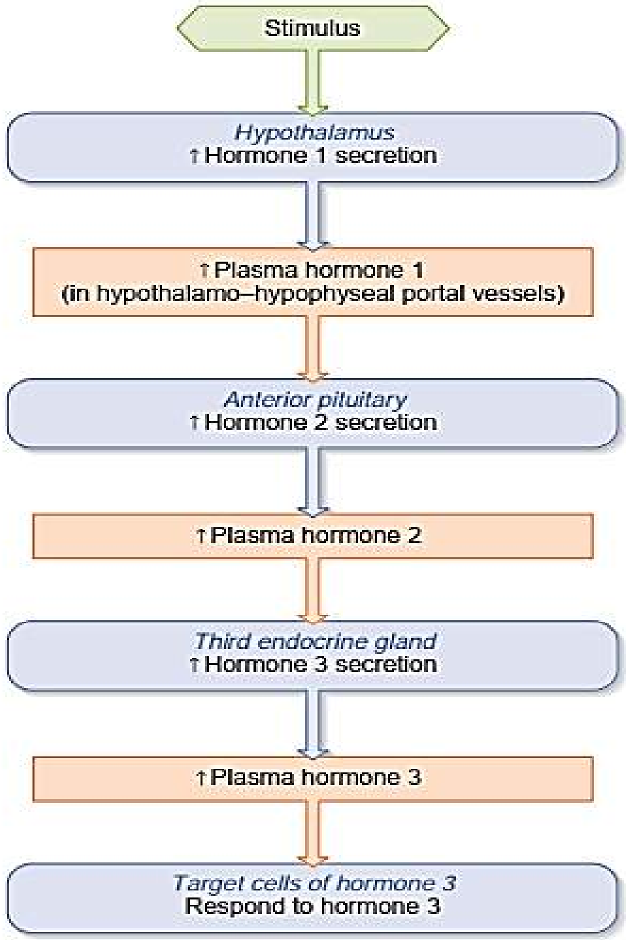
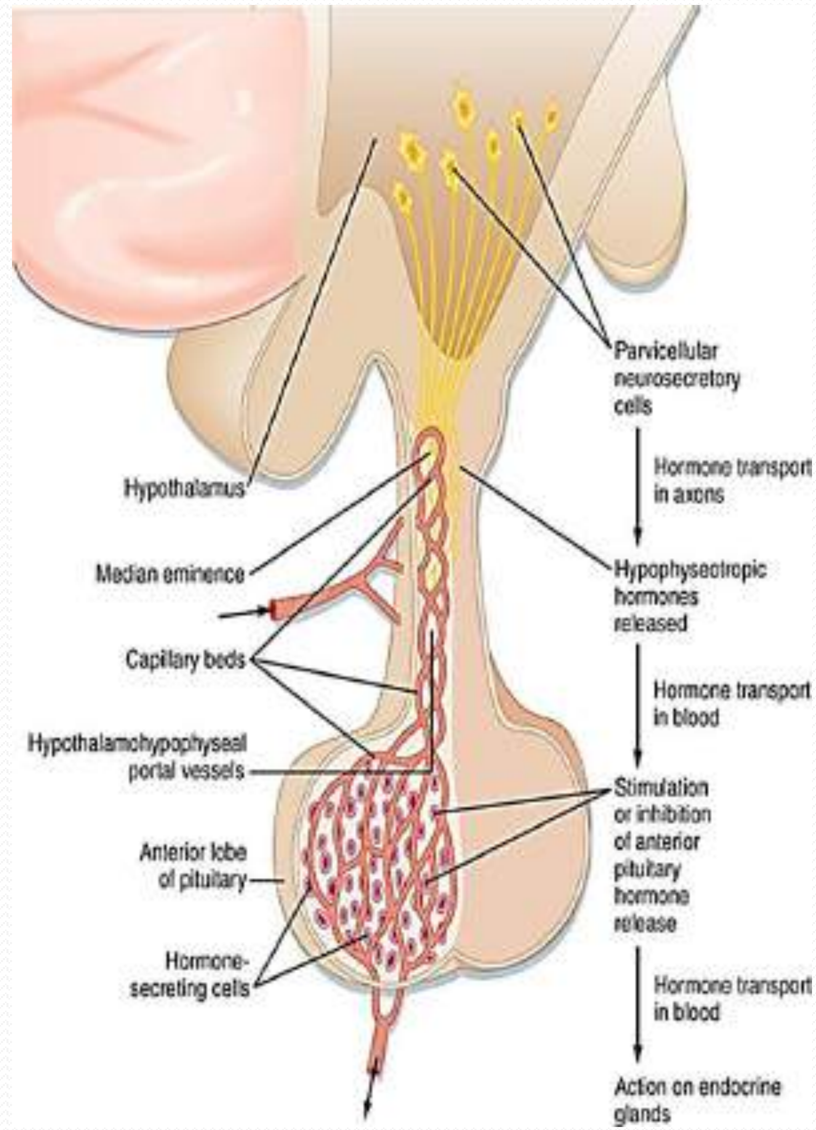


Figure 11.14 Typical sequential pattern by which a hypophysiotropic hormone (hormone 1 from the hypothalamus) controls the secretion of an anterior pituitary gland hormone (hormone 2), which in turn controls the secretion of a hormone by a third endocrine gland (hormone 3). The hypothalamo–hypophyseal portal vessels are illustrated in Figure 11.13.



2. Feedback Control

Negative feedback mechanisms

Long Loop Feedback

- **Long loop feedback means the effect of the target gland hormones on the secretion of both the hypothalamic hypophysiotropic hormones and pituitary tropic hormones i.e. either at a hypothalamic or pituitary levels.**
- **The inhibitory effect is called negative feedback (more common).**

N.B. If this effect is stimulatory, the feedback is positive.

- **<u>Example:</u>**

Stress stimulates the hypothalamus → Release of CRH → Anterior Pituitary ↑→ ACTH → carried by blood to adrenal cortex → ↑ Cortisol → inhibits hypothalamic CRH and pituitary ACTH. (**negative feedback**).

- **Long-loop feedback does not exist for prolactin because this is one anterior pituitary gland hormone that does not have major control over another endocrine gland.**

Short Loop Feedback

The influence of anterior pituitary gland hormone on its associated hypothalamic hormone is known as a short-loop negative feedback.

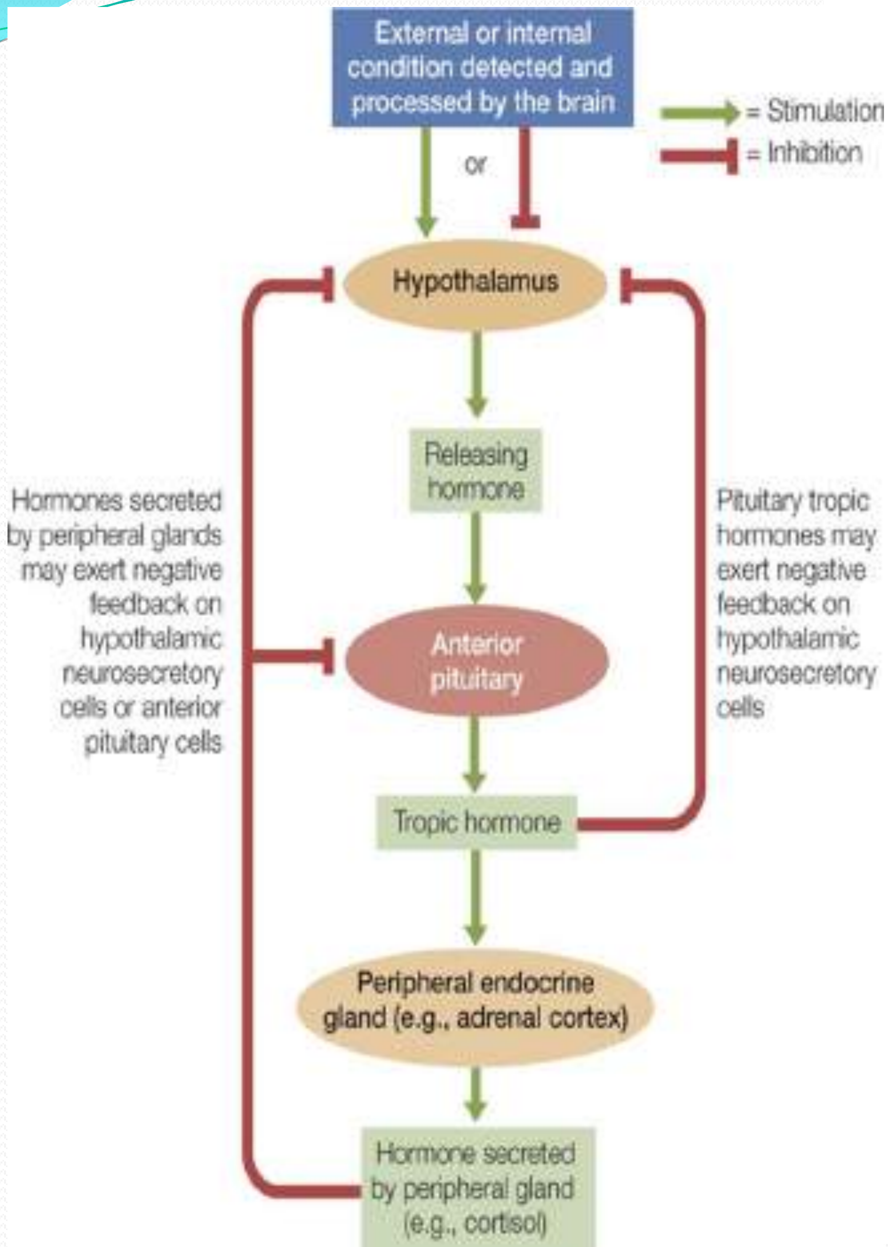
Example:

The anterior pituitary hormone itself acts upon the hypothalamus as in case of prolactin to stimulate the secretion of dopamine, which then inhibits the secretion of prolactin.

N.B. Ultrashort-loop feedback*, in which secretion of a hypothalamic hormone is inhibited by that same hormone*

Importance of the negative feed back control :

- Maintain the normal level of the target gland hormone in blood.
- Prevent over stimulation of the target gland by the corresponding tropic hormone.
- Adjust the rate of secretion of the target gland hormones according to the body need.



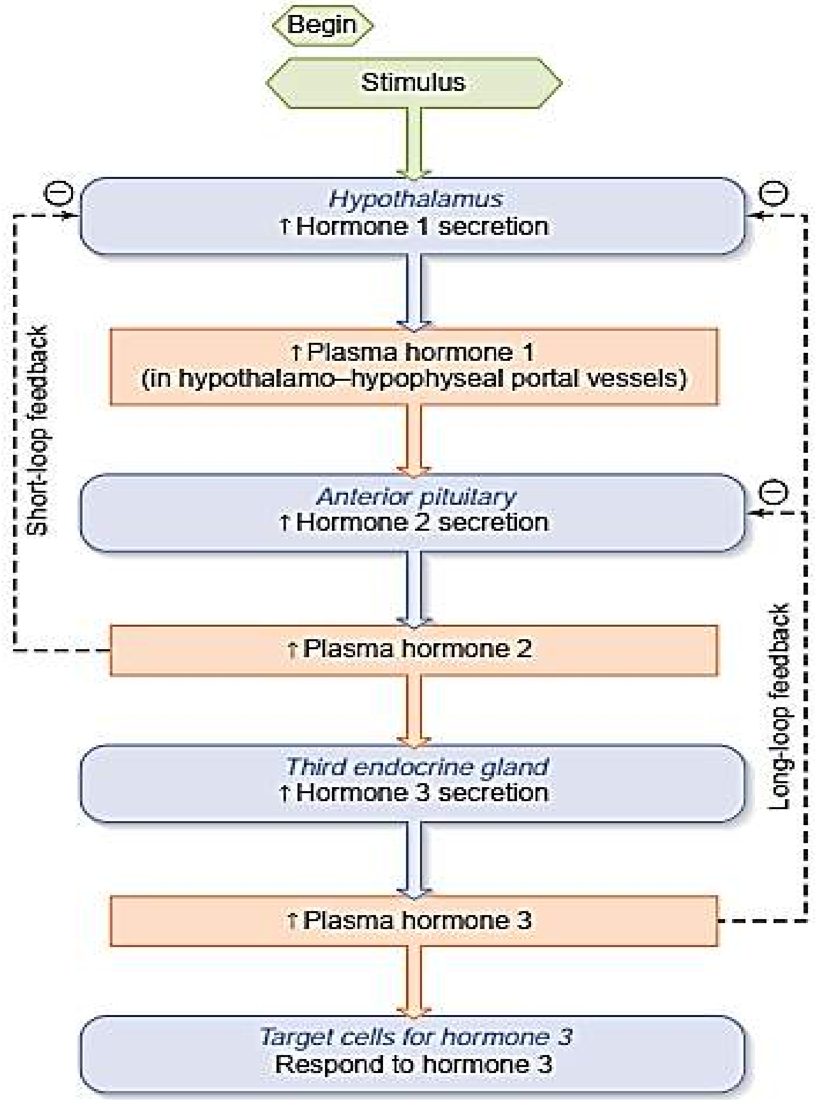


Figure 11.19 Short-loop and long-loop feedbacks. Long-loop feedback is exerted on the hypothalamus and/or anterior pituitary gland by the third hormone in the sequence. Short-loop feedback is exerted by the anterior pituitary gland hormone on the hypothalamus.

Positive Feedback

- Although **negative feedback is the primary homeostatic mechanism in the endocrine system**, there are **rare examples of positive feedback**.
- The prime example of **positive feedback occurs during the ovarian cycle.**
- In the late follicular phase of the cycle, **estradiol levels rise above a critical point, above which positive feedback occurs**.
- The **high estradiol concentration results in a surge in hypothalamic secretion of GnRH and pituitary secretion of LH and FSH, inducing ovulation**. Ovulation and transformation of ovarian follicular cells into the corpus luteum signals the end of positive feedback.

The Role of “Nonsequence” Hormones on the Hypothalamus and Anterior Pituitary Gland

- There are stimulatory and inhibitory hormonal influences on the hypothalamus and/or anterior pituitary gland other than those that fit the feedback patterns.
- In other words, a hormone that is not itself in a particular hormonal sequence may nevertheless exert important influences on the secretion of the hypophysiotropic or anterior pituitary gland hormones in that sequence.
- **For example, estradiol markedly enhances the secretion of prolactin by the anterior pituitary gland, even though estradiol secretion is not normally controlled by prolactin.**

Receptor Regulation in Endocrine System

- The cellular response to a hormone is dependent on the presence of specific receptors for the hormone.
- Regulation in the endocrine system can occur at the level of hormone receptors, by **altering the number of receptors** or **their binding affinity for a hormone.**
- In some cases, hormones induce **down-regulation** (reduction) of the number of their receptors or of the binding affinity of their receptors, as **a type of negative feedback**.
- Hormones may also produce **receptor up-regulation**, in which the number or affinity of receptors is increased.

Thank You